From Woodbridge et al. 2009 Klamath Province Working Group:
Ecological baseline for conservation of northern spotted owls in the Klamath Province

2.b. Home ranges

Burt (1947) provided a conceptual definition of an animal's home range: "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young". To be useful for conservation and management of NSO at local scales, however, this definition must be expanded to explicitly incorporate temporal scale (season, annual, individual's life span) and internal structure (areas of concentrated use). Internal structure of NSO home ranges is the result of use patterns associated with different behaviors such as nest tending, sheltering by recently fledged young, defense of resources, and foraging. As the relative importance of each of these behaviors shifts seasonally and among years, the areal extent of, and patterns of use within, NSO home ranges are flexible. While it is reasonable to assume that variation in the use of space by individual NSO is also influenced by the amount and distribution of habitat and prey resources, our objective is to identify central tendencies or patterns that may be used to inform modeling and design of conservation strategies.

Home range size –

Quantifying the spatial extent of NSO home ranges has important implications for understanding habitat use and ecological relationships of this species. The sizes of NSO home ranges appear to be influenced by a variety of factors, including geographic differences in diets and habitat characteristics (Carey *et al.* 1992, Zabel *et al.* 1995); it is commonly accepted that the spatial extent of NSO ranges generally decrease along a gradient from north to south (USFWS

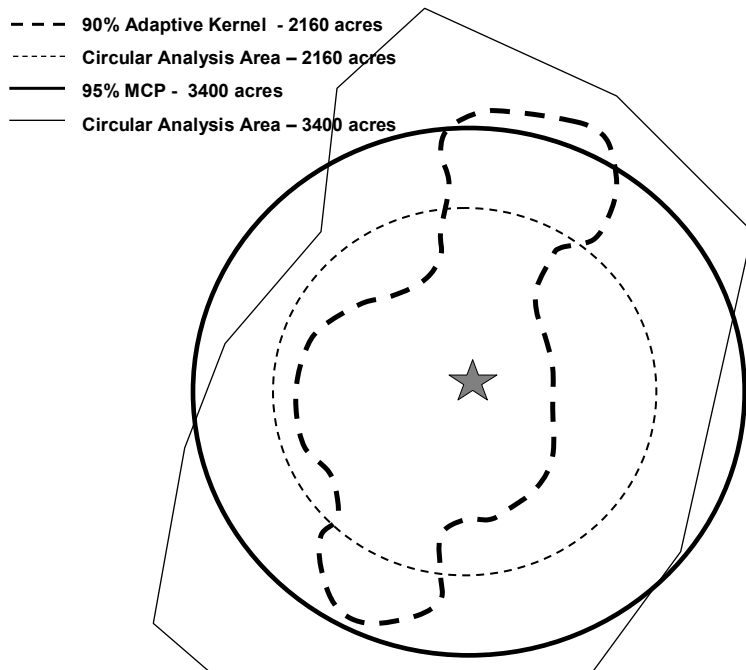2008). We therefore restricted this assessment to home range studies conducted within the Klamath Province.

Estimates of home range size are also important for developing management prescriptions and evaluating impacts of human activities on NSO. For the purpose of quantifying habitat and the impact of proposed modification of habitat, median home range estimates from radio telemetry studies are transformed into circular 'analysis areas' that are used as surrogates for actual home ranges (Fig. 2.b.1). Based on the median MCP home range estimate for NSO pairs in the Klamath Province, the FWS currently uses a circular analysis area of 1.3 mile radius (3,398 acres; Thomas *et al.* 1990, USFWS 1992). While this practice provides a practical and uniform method for quantifying NSO habitat, the correspondence of circular analysis areas with areas actually used by NSO remains questionable. Landscape pattern, both in terms of topographic features and vegetation pattern, may result in non-circular patterns of use by owls (Anthony and Wagner 1999).

There are numerous analytical techniques for estimating home range sizes based on animal locations (reviewed in Powell 2000). One of the most commonly used classes of home range estimators is the minimum convex polygon (MCP). Because MCP consists of a single polygon encompassing all or the majority of telemetry locations, this method may be viewed as providing a representation of the area *containing* the home range, including unused and infrequently used areas (Powell 2000, Laver and Kelly 2008). Generally biased large, MCP home range estimates provide relatively conservative values on which to base the size of habitat-analysis areas. Other home range estimators such as utilization distributions (e.g., kernel density estimates: see Powell 2000) de-emphasize areas less frequently used and typically yield smaller home range estimates that, when converted into circular analysis areas, may exclude distant, but

potentially important, patches of habitat (see Figure 2.b.1). At the upper end of utilization

distributions (e.g.; 90-100%), however, kernel estimates may resemble MCP polygons and

circular analysis areas (Anthony and Wagner 1999).

Our understanding of space use by NSO is limited by lack of comparability among

published studies due to variation in estimation methods, duration and seasonality of data

collection, and whether estimates are for individuals or pairs. By looking for commonalities

among studies and using a "strength of evidence" approach, however, we can evaluate whether

the available information provides broadly modal values that are useful for conservation

planning. Because the primary purpose of this review is to evaluate appropriate spatial scales for

conservation planning and modeling of breeding populations, we have focused on conservative

estimates of year-round (annual) space use by NSO pairs.

Figure 2.b.1: Comparison of MCP and adaptive kernel home range estimates with
corresponding circular analysis areas

Legend:
- – – 90% Adaptive Kernel - 2160 acres
- ······ Circular Analysis Area – 2160 acres
- ── 95% MCP - 3400 acres
- ─ Circular Analysis Area – 3400 acres

Home range studies conducted in the Klamath Province generally support the use of a 1.3 mile radius analysis area, as this distance is encompassed by the confidence intervals of nearly all the home range studies we compiled. (see Figure 2.b.2). Carey *et al.* (1992) found that the sizes of NSO pairs' home ranges were related to the type of forest and the degree of forest fragmentation (Table 2.b.1). Pairs' home ranges in clumped, old forest were substantially smaller then those in fragmented forests. The authors suggested that management areas should be slightly larger than 1.3 miles, however, to encompass oblong-shaped home ranges. Zabel *et al.* (1993) provided estimates of pairs' home ranges in two different study areas in the region (see Table 2.b.2). They did not report the sizes of pairs' annual home ranges, but the average sizes of pairs' nonbreeding season home ranges were similar to the current 3,410-acre guideline. Annual home ranges of pairs would likely be larger than these values because their breeding- and nonbreeding-season home ranges probably do not completely overlap. In a different study, the

average cumulative MCP home range size for 9 pairs in the Medford, Oregon area was 3,971 acres (SD=1,063 acres; Wagner and Meslow 1989). Irwin *et al.* (2006) estimated the sizes of paired individuals' cumulative home ranges in 3 study areas in the region (see Table 2.b.3). Study area means ranged from approximately 4000 to 5000 acres, but pairs' home ranges would likely be larger due to incomplete home range overlap among pair members.

Because of differences in methodology between recent studies and those originally used to support the 1.3-mile radius (3,410 acres) analysis area (Thomas *et al.* 1990, USFWS 1992), the results cannot be rigorously compared (see Powell 2000, Laver and Kelly 2008). Nonetheless, the majority of recent home range studies suggest that MCP home range estimates for NSO pairs in the Klamath Province average between 4000 and 5000 acres (Figure 2.b.2); a somewhat larger area than the home range analysis area currently used by FWS.

Figure 2.b.2: Mean minimum convex polygon home range sizes (acres) for northern spotted owls in the Klamath Province, CA and OR. Error bars represent ±1 standard deviation. Horizontal line shows the size of the Fish and Wildlife Service guidelines' outer analysis area (3,410 acres).
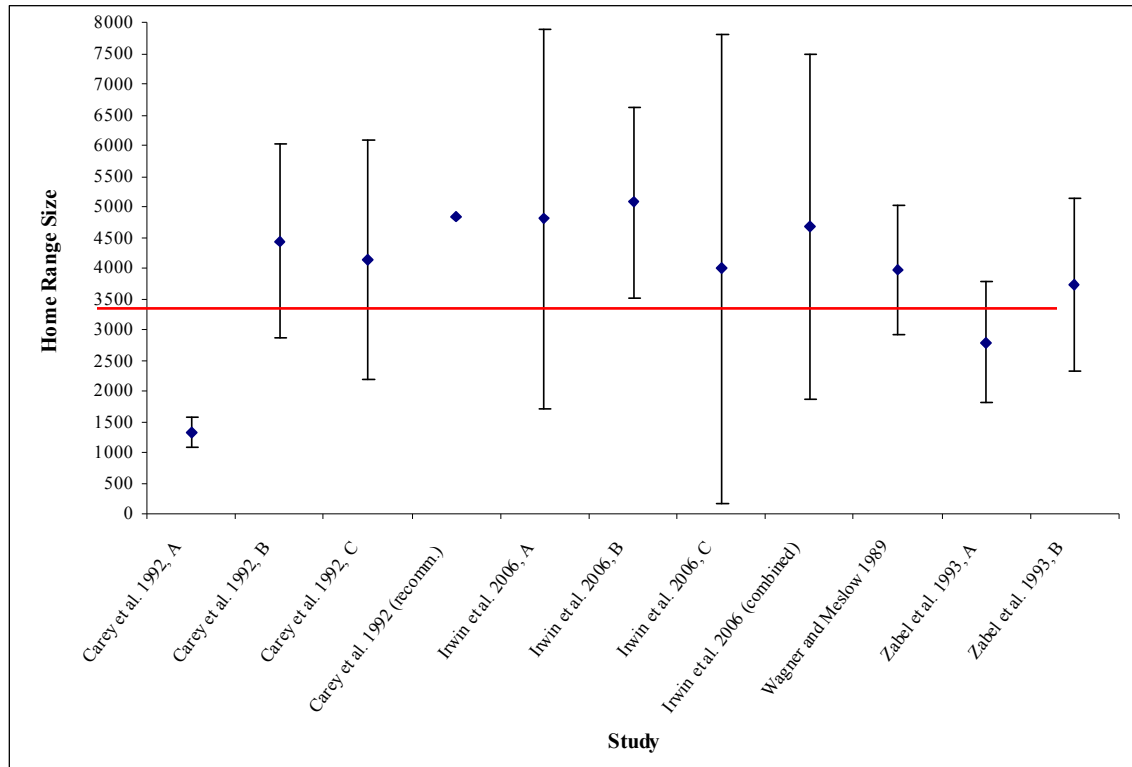
Carey et al. 1992 = pairs' annual home ranges, A = Klamath Mountains, clumped forest, B = Klamath Mountains, fragmented forest, C = Umpqua, fragmented forest; Irwin et al. 2006 = paired-individuals' annual home ranges, A = Hilt, B = Medford, C = Yreka; Zabel et al. 1993 = pairs' nonbreeding-season home ranges, A = Mad River, B = Ukonom.

Table 2.b.1: Minimum convex polygon estimates of annual home range sizes (acres) for northern spotted owl pairs within different types of forest in the Klamath Province, Oregon (Carey *et al.* 1992).

Area*	No. Pairs	Mean	SE
MCC	3	1317	143
MCF1	5	4139	870
MCF2	6	4438	645
Recommended	-	4843	-

*MCC = mixed-conifer, clumped, Klamath Mountains old forest; MCF1 = mixed-conifer, fragmented, Umpqua River Valley, old forest; MCF2 = mixed-conifer, fragmented, Klamath Mountains old forest.

Table 2.b.2: Minimum convex polygon (100%) estimates of home range sizes (acres) for northern spotted owls in the Klamath Province, California (Zabel *et al.* 1993).

Study Area	Mad River		Ukonom	
	Mean	SD	Mean	SD
Individuals				
NB*	1989	890	2572	857
B*	1043	447	1460	578
A*	2456	1124	2847	1374
Pairs				
NB*	2787	986	3721	1409
B*	1436	368	1900	756

*NB = nonbreeding season home range; B = breeding season home range; A = annual home range.

Table 2.b.3: Estimated cumulative (100% minimum convex polygon) home range sizes (acres) for selected* territorial individual northern spotted owls in the Klamath Province, California (Irwin *et al.* 2006).

Study Area	Yreka	Medford	Hilt	Combined
No. Individuals	7	9	10	26
Mean	3987	5073	4805	4678
SD	3819	1557	3098	2816

*Excludes owls that did not exhibit normal ranging behavior (i.e., moved to new territory, or influenced by active timber harvest).

Home range use - core areas

Resources such as food and breeding and resting sites are patchily distributed in heterogeneous landscapes such as those prevalent within the Klamath Province. In such landscapes, animals are likely to disproportionately use areas that contain relatively high densities of important resources (Powell 2000). These disproportionately used areas are referred to as core areas. One of the most influential studies of wildlife core areas was focused on NSOs in northern California (Bingham and Noon 1997). Although this study's sample size was small, it used an unusually rigorous method for determining the sizes of core areas (Powell 2000). Bingham and Noon (1997) noted that the combined size of NSO pair members' core areas is

probably more meaningful than the sizes of individuals' core areas. This is because pair members likely minimize spatial overlap in order to increase overall pair fitness. Bingham and Noon (1997) estimated core areas by evaluating the ratio of total home range area to the area encompassing different adaptive kernel utilization distributions (UD), and found that individual NSOs in northern California spent 60 to 75% of their time in their core areas, which comprised only 21 to 22% of their home ranges. The mean core area size for NSO pairs in the Klamath Province was 411 acres (166 ha; SE=26 ha; range=168-455 acres [68-184 ha]; n=7 pairs). Bingham and Noon (1997) also recommended that management guidelines attempt to meet the area requirements of most individuals in a population by accounting for variability in core area size; for example, by using the mean core area size plus one standard error. The addition of one standard error to the mean size of pairs' core areas totaled 475 acres (192 ha) for the Klamath Province data set. NSO core areas had diverse shapes due to variation in the distribution of foraging and roosting locations (Bingham and Noon 1997). However, assuming a circular shape for the purposes of evaluating and managing habitat, an area this size would have a radius of 0.49 mile. Carey and Peeler (1995) found remarkably similar results outside the Klamath Province, in southern Oregon.

We evaluated home range estimates from other studies in the Klamath Province in light of these patterns. By approximating Bingham and Noon's (1997) methodology, we evaluated kernel estimates in Irwin et al. (2004; Table 2) to estimate core area size (only 50%, 75% and 95% UD estimates were available). The 75% fixed kernel estimate accounted for 21 to 27% of the total (95%) home range, and the 75% adaptive kernel accounted for 23 to 30%, suggesting that a UD somewhat lower than 75% would yield core area estimates very similar to those obtained by Bingham and Noon (1997). The addition of one standard error to individuals' mean

50% and 75% kernel density home range estimates from three different study areas in the province suggested that 500-acre analysis areas would include much of the important habitat for most breeding NSO (Irwin *et al.* 2004, Table 2.b.4). Application of the same criteria to the results of a telemetry study in southwestern Oregon suggested that pairs used somewhat larger core areas than in other parts of the Klamath Province (Anthony and Wagner 1999, Table 2.b.5). Much of this study area is comprised of a checkerboard of public lands and industrial timberlands (Anthony and Wagner 1999, Dugger *et al.* 2005). To the extent that the amounts, quality, or contiguity of habitat have been reduced on these timberlands due to timber harvesting, NSOs in this area may have larger area requirements than in parts of the province with less harvesting (Carey *et al.* 1990, 1992, Zabel et al. 1992, 1995).

Table 2.b.4: Fixed kernel and adaptive kernel cumulative home range estimates (acres) for individual northern spotted owls in the Klamath Province (Irwin *et al.* 2004)

Study Area	Yreka	Medford	Hilt	Combined
No. Individuals	9	10	11	30
No. Telemetry Points	3151	5041	2414	10606
50% Fixed Kernel				
Mean	128	210	147	162
SE	18	26	22	14
Mean + 1 SE	146	236	169	**176**

75% Fixed Kernel				
Mean	364	510	435	439
SE	38	47	54	29
Mean + 1 SE	402	557	489	**468**
50% Adaptive Kernel				
Mean	239	303	262	269
SE	47	39	42	24
Mean + 1 SE	286	342	304	**293**
75% Adaptive Kernel				
Mean	584	706	673	657
SE	124	68	91	54
Mean + 1 SE	708	774	764	**711**

Table 2.b.5: Adaptive kernel home range estimates (acres) for northern spotted owl pairs in southwestern Oregon (Anthony and Wagner 1999)

Utilization Distribution	50%	75%
Mean	413	1443
SE	67	259
Mean + 1 SE	**480**	**1702**

The territorial spacing of NSOs provides an alternative approach for evaluating the core area concept. An individual's territory is thought to be the portion of the home range that both contains important resources and is economically defensible (Meyer *et al.* 1998). Therefore, average territory size provides a useful scale at which to evaluate core area habitat. Wildlife biologists frequently use half the mean or median nearest neighbor distance to estimate the size of the defended portions of home ranges, or the portions of home ranges that are used exclusively by resident pairs (e.g., Reynolds and Joy 1998). Half the mean and median nearest neighbor distances for nesting NSO near Willow Creek were 0.49 mile (0.79 km: Hunter *et al.* 1995) and 0.44 mile (0.71 km: Franklin *et al.* 2000), respectively.

A third approach for evaluating the core area is provided by studies that modeled habitat relationships of NSO in the Klamath Province. Two studies in the region found that habitat within a 0.5-mile radius of nests differed more strongly from the general landscape compared with larger areas around nests (Hunter *et al.* 1995, Meyer *et al.* 1998). While these results do not necessarily indicate that NSO are most selective of habitat at the core scale, they do show that evidence of habitat selection by NSO is weaker at scales larger than this. Stronger support for the validity of assessing and managing habitat at the this scale is provided by studies that modeled habitat-based fitness (Franklin *et al.* 2000, Dugger *et al.* 2005) and presence (Zabel *et al.* 2003) for NSO in the region. These studies found that important NSO-habitat relationships were well-captured at scales of 0.44 to 0.50 mile around activity centers.